Cryogenic Refractive Indices of S-LAH55, S-LAH55V, S-LAH59, S-LAM3, S-NBM51, S-NPH2, S-PHM52, and S-TIH14 Glasses

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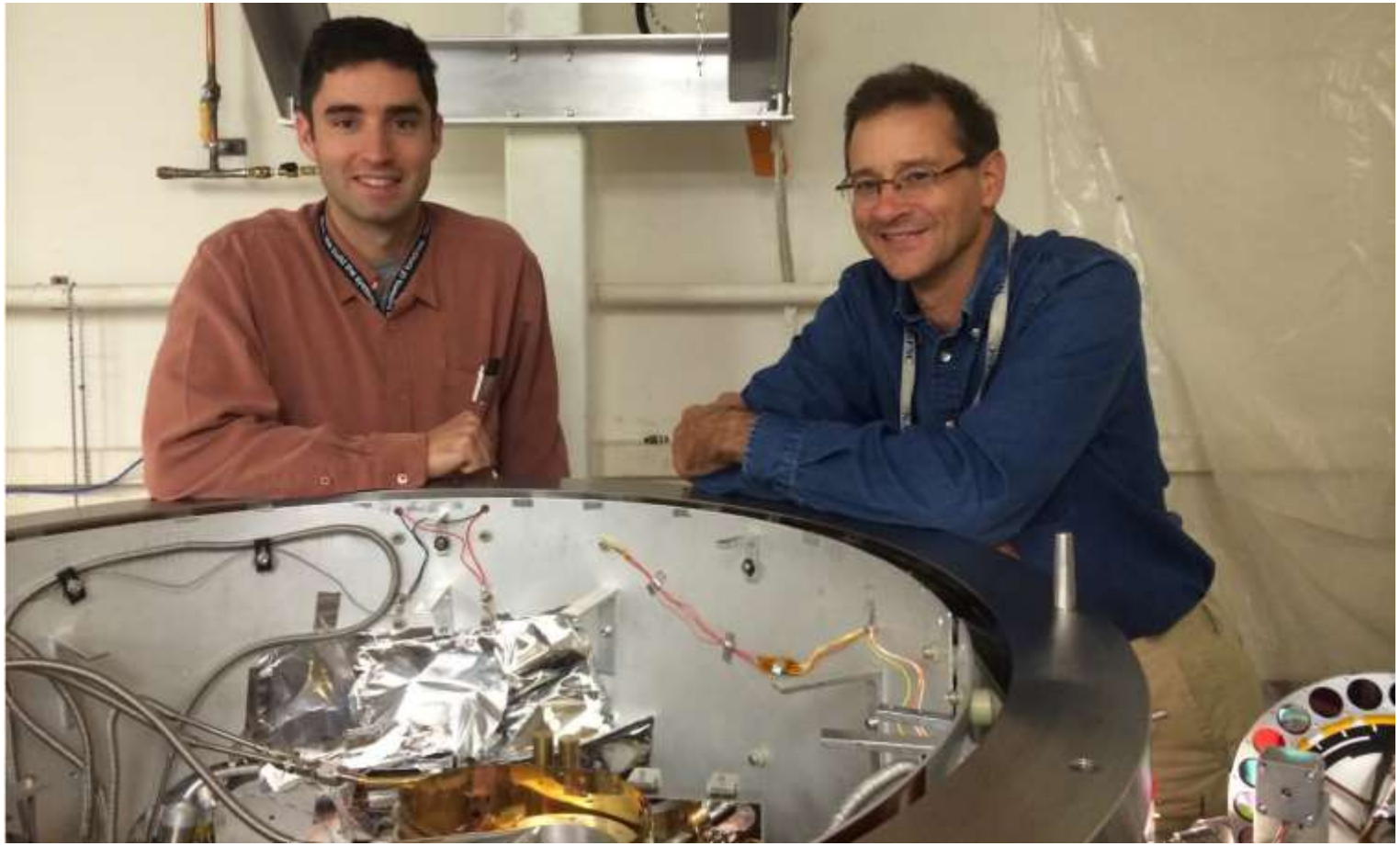
K.H.M. and D.B.L. with the Cryogenic High Accuracy Refraction Measuring System (CHARMS) at NASA GSFC

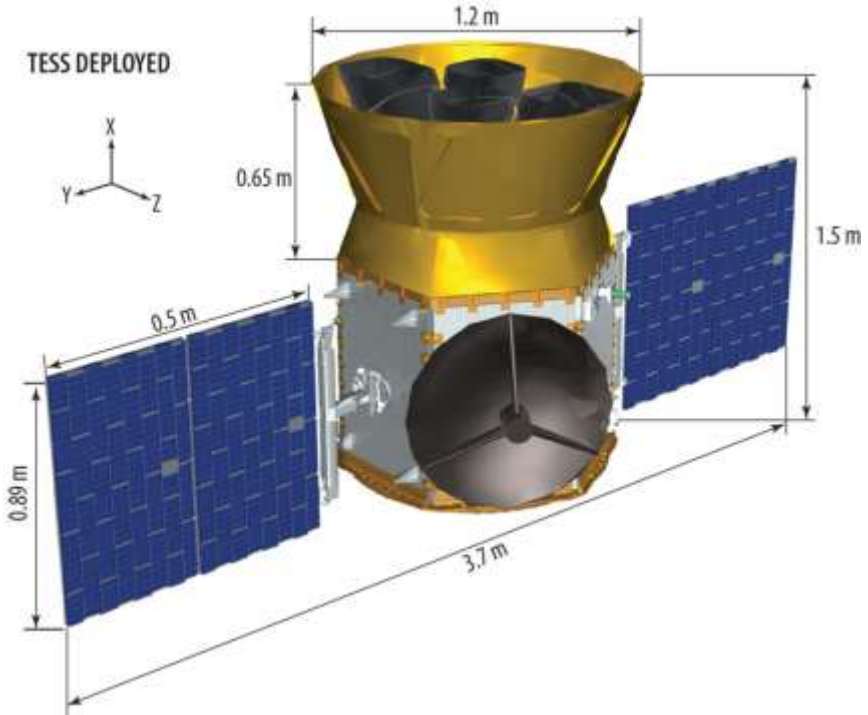


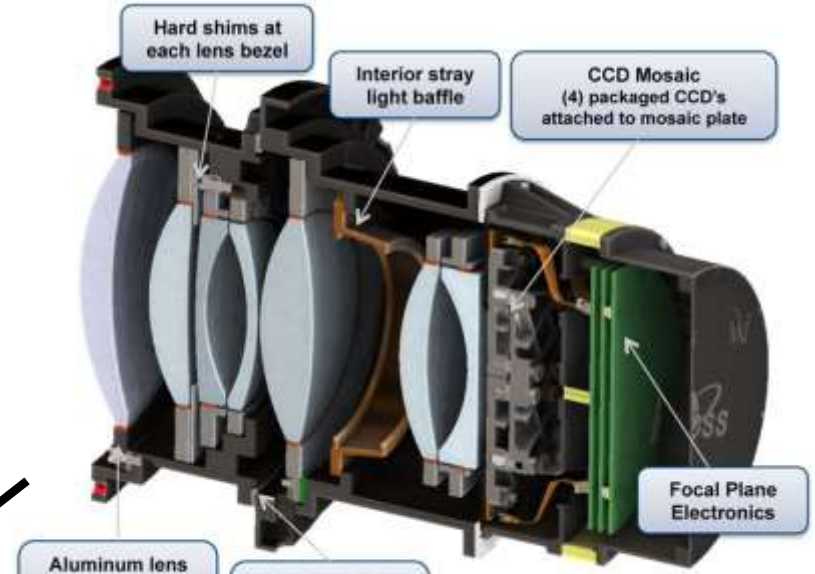
Outline of Slides

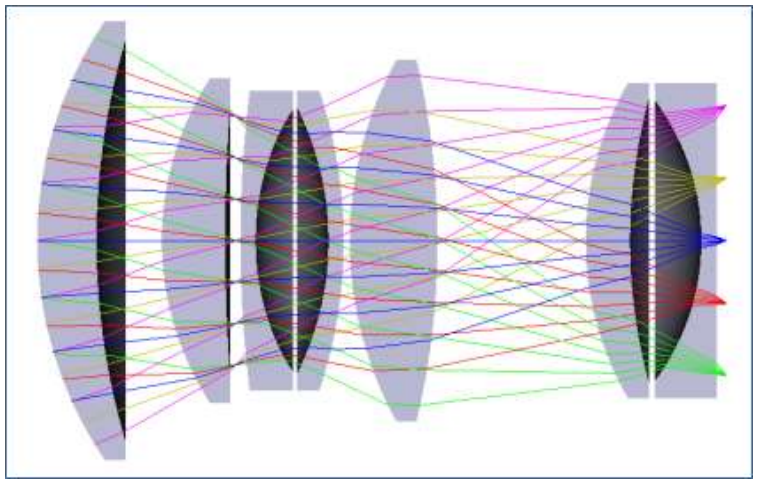
- Motivation for measurements (TESS mission)
- CHARMS: operation and capabilities
- CHARMS: cryogenic capabilities
- Ohara glass map and nomenclature
- First evidence of intra-melt variability in S-LAH55V
- Optical properties of “high” index prisms
- Optical properties of “middle” index prisms
- CHARMS measurements compared to literature values

Motivation: Transiting Exoplanet Survey Satellite (TESS)

- Planet finder
- 2017 Launch date (Cape Canaveral, FL)
- Highly Elliptical Earth Orbit
- 4 identical cameras 90° X 90° FOV
- 600 – 1000 nm bandpass







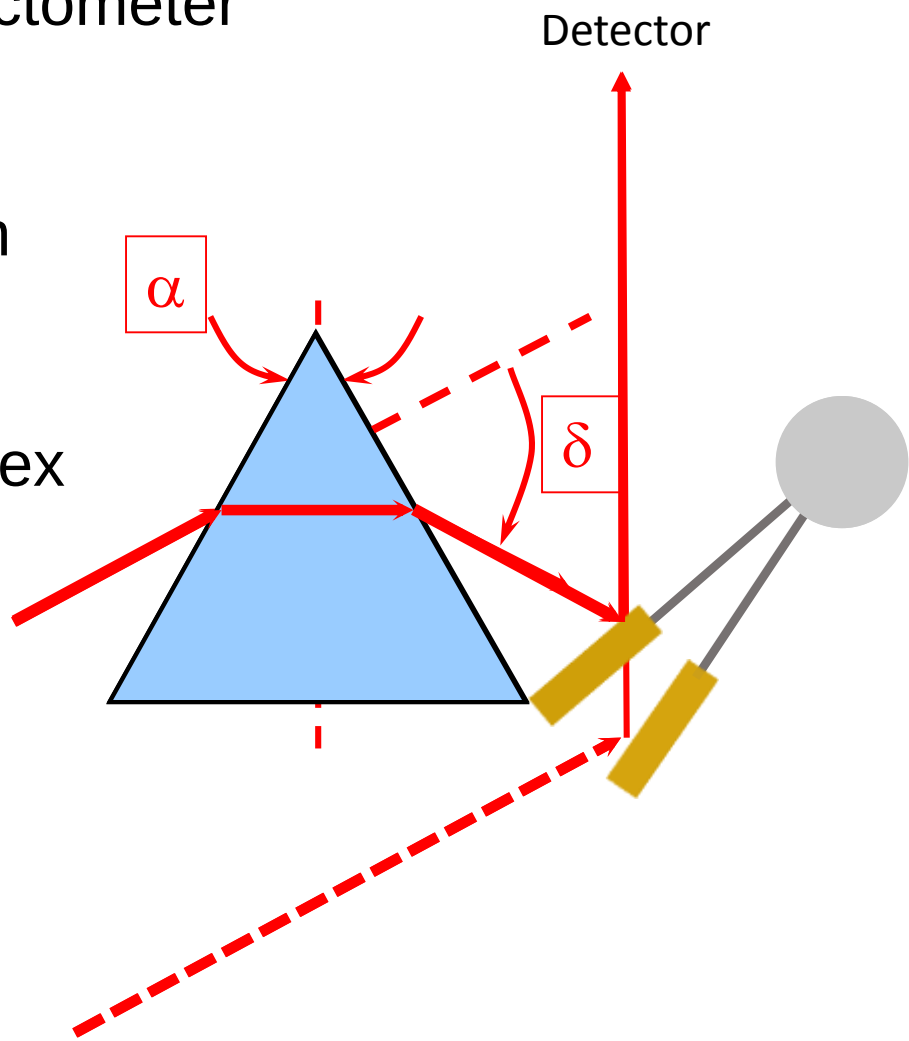
Hybrid Petzval design

CHARMS: Operation and Capabilities

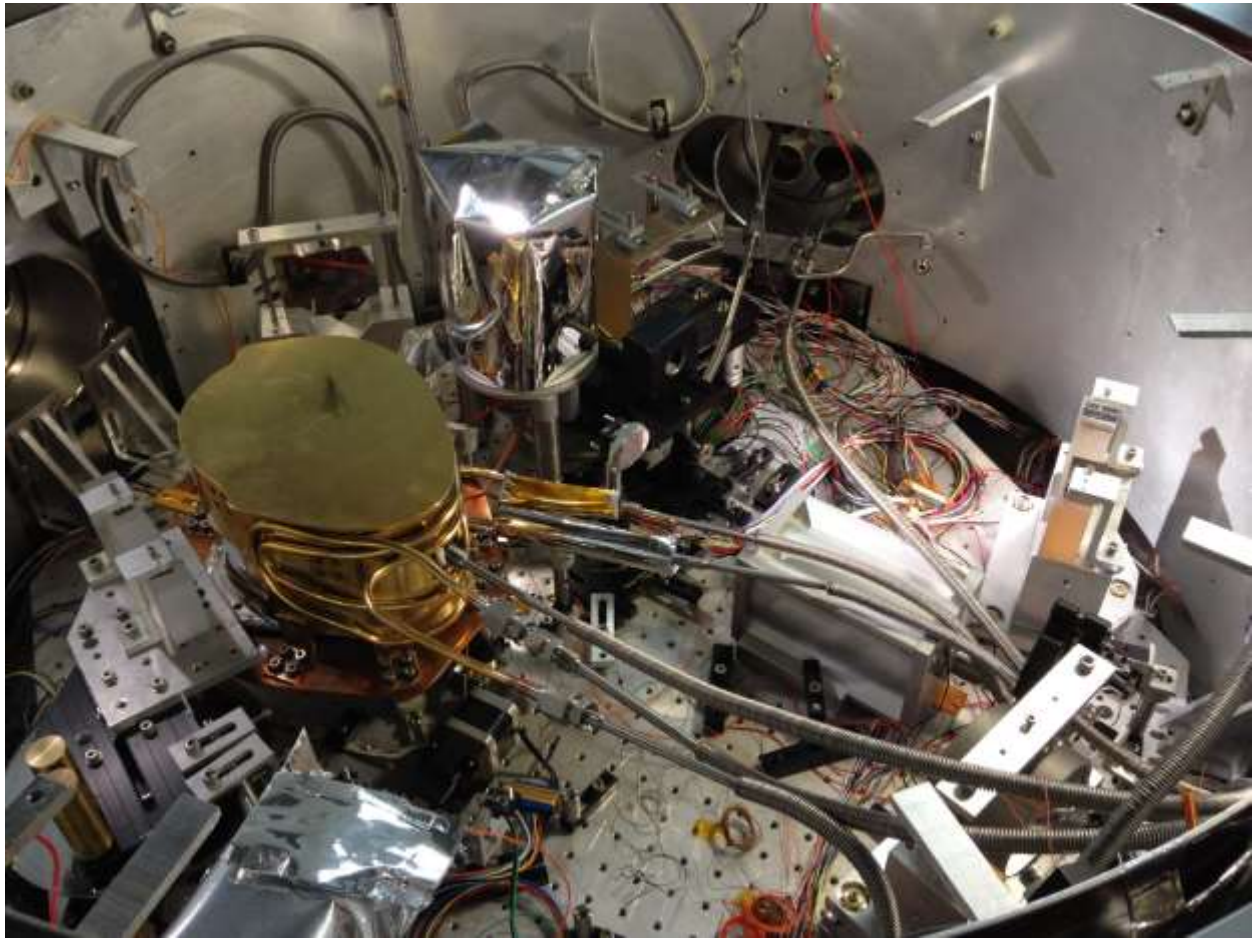
- CHARMS is a minimum deviation refractometer
- Five simple steps:

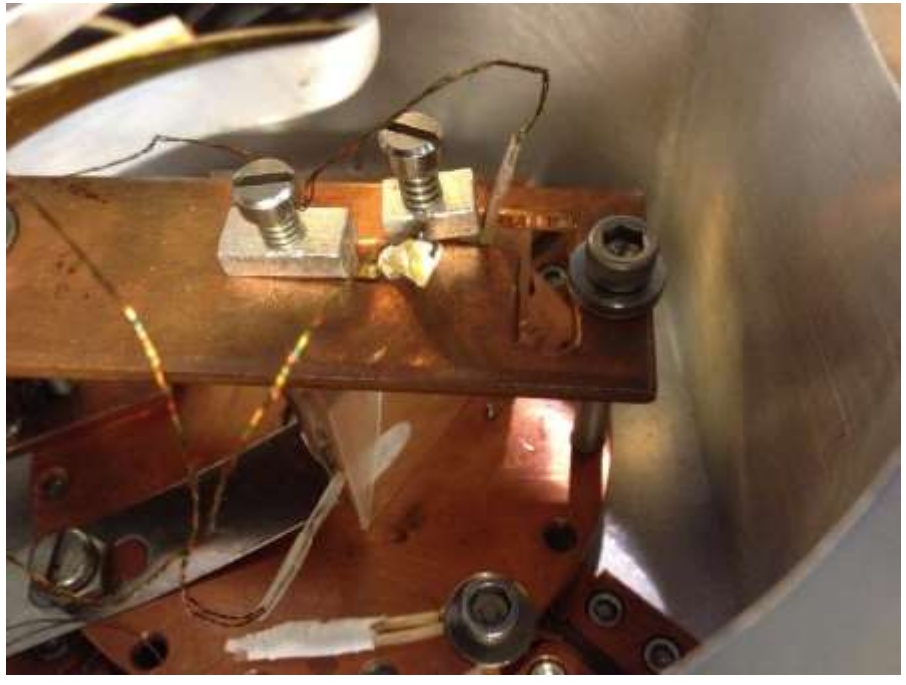
1. Measure the apex angle of the prism
2. Establish the condition of min deviation
3. Measure angle of undeviated beam
4. Measure angle of deviated beam
5. Compute deviation angle; compute index

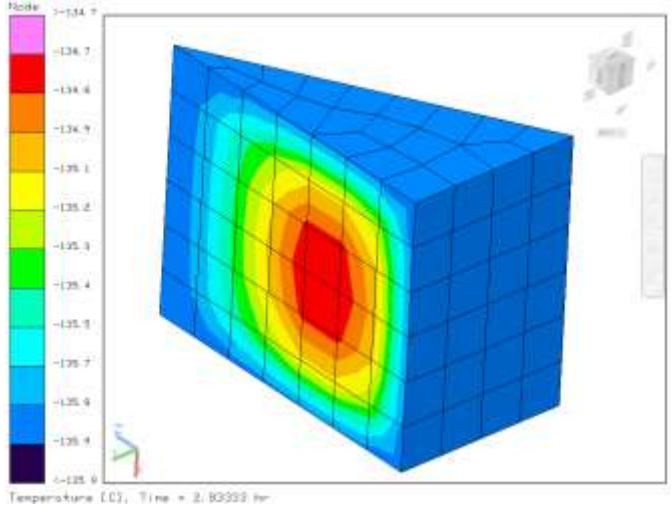
$$n = \frac{sin(\frac{\alpha+\delta}{2})}{sin(\frac{\alpha}{2})}$$



CHARMS: Cryogenic Capabilities







Courtesy of
S. Scola

CHARMS: data reduction and presentation style

$$n^2(\lambda,T)-1 = \sum_{i=1}^{3} \frac{S_i(T)\cdot\lambda^2}{\lambda^2-\lambda_i^2(T)}$$

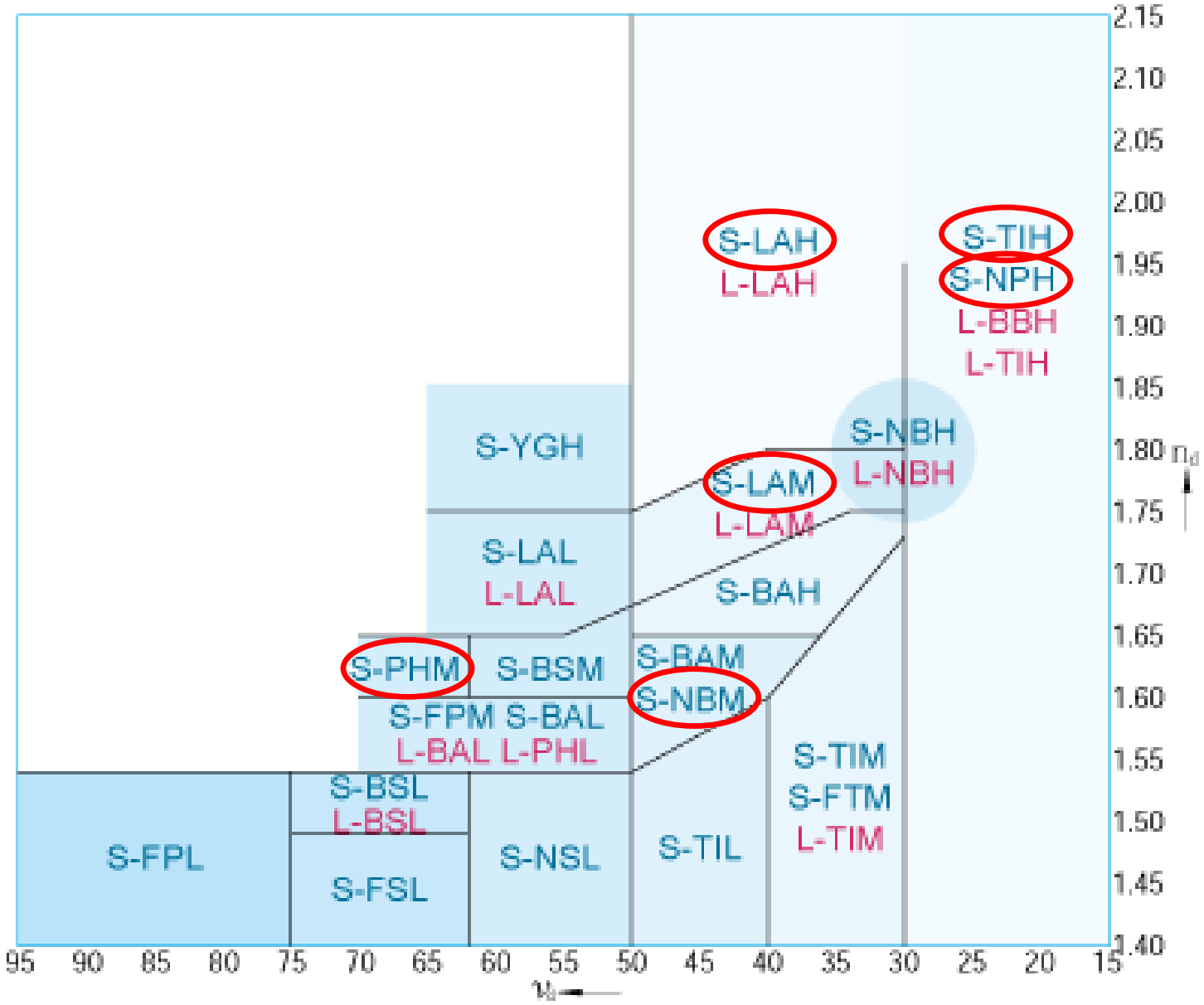
$$S_i(T) = \sum_{j=0}^{3} S_{ij}\cdot T^j$$

$$\lambda_i(T) = \sum_{j=0}^{3} \lambda_{ij}\cdot T^j$$

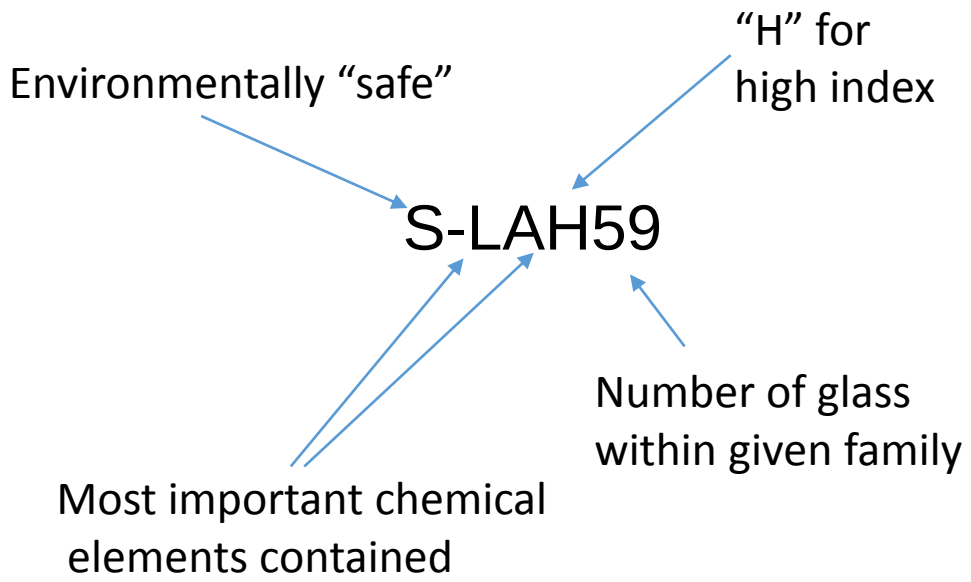
$$AAR = \frac{\sum_{k=1}^{n} |index_{measured} - index_{fit}|}{n}$$

Prism ID	average absolute residual
S-LAH55	4.4E-6
S-LAH55V-1	3.7E-6
S-LAH55V-2	3.6E-6
S-LAH59	3.6E-6
S-TIH14	5.2E-6
S-NPH2	7.1E-6
S-LAM3	3.7E-6
S-NBM51	2.6E-6
S-PHM52	3.5E-6

Ohara Glasses

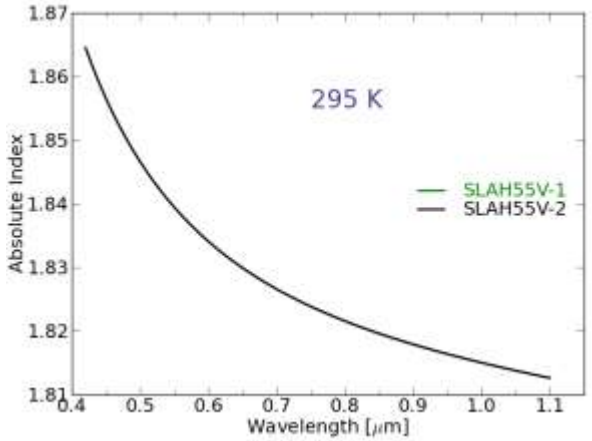


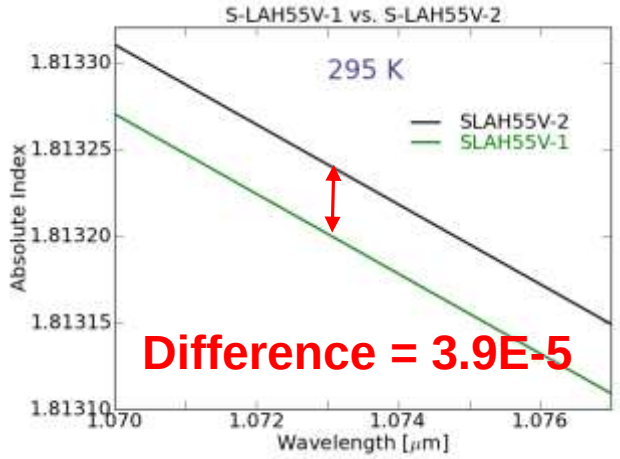
Ohara nomenclature example:

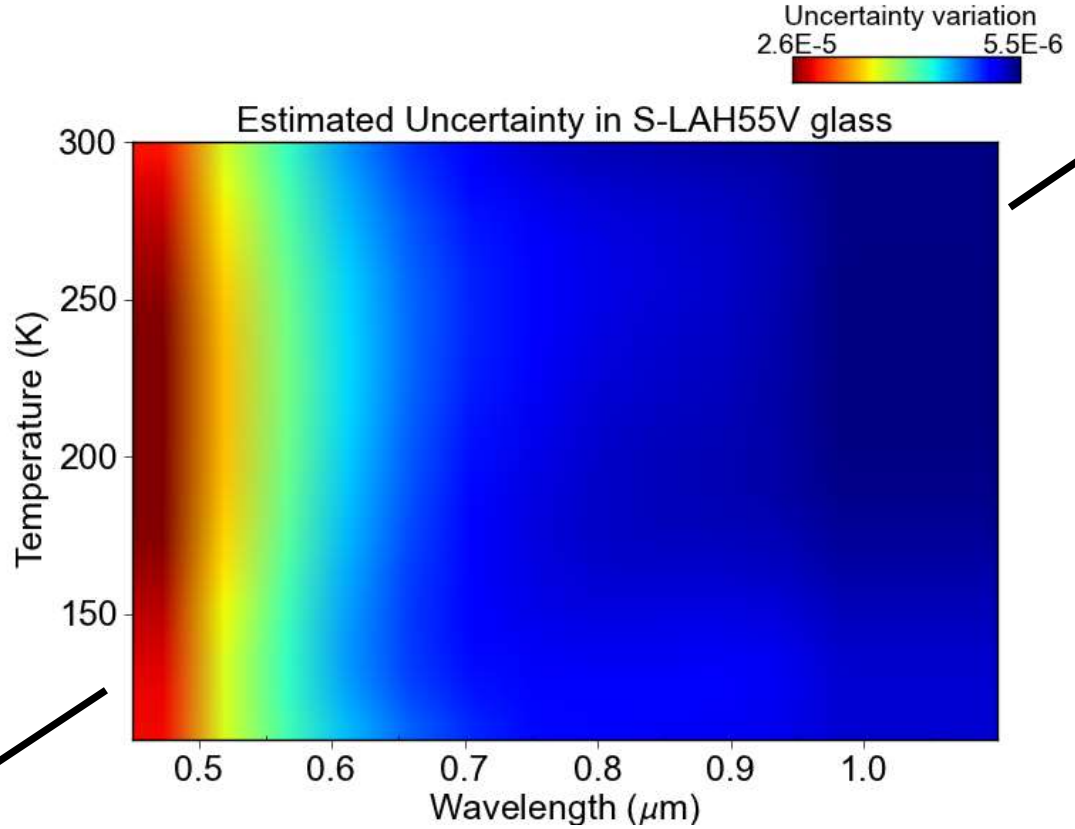


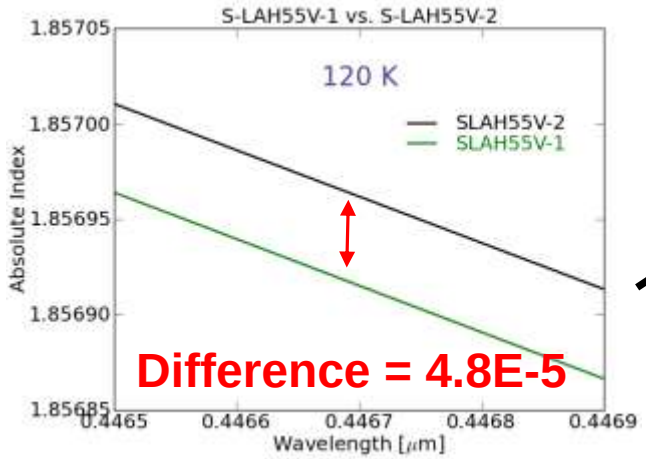
S-LAH55 vs. S-LAH55V

S-LAH55V: Intra-melt Variability

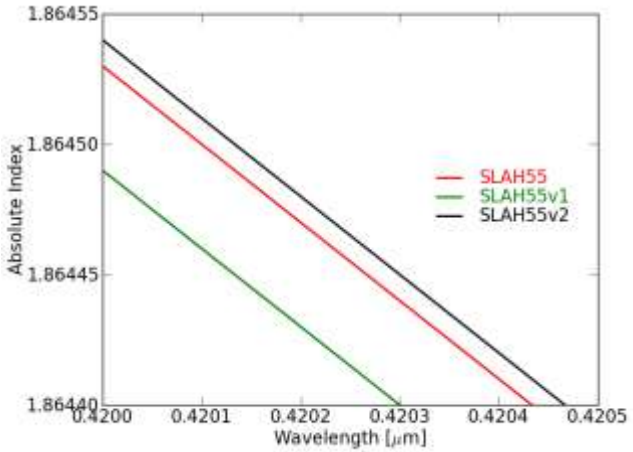


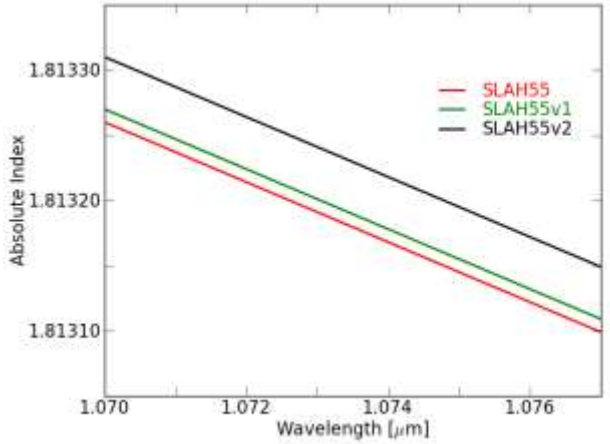


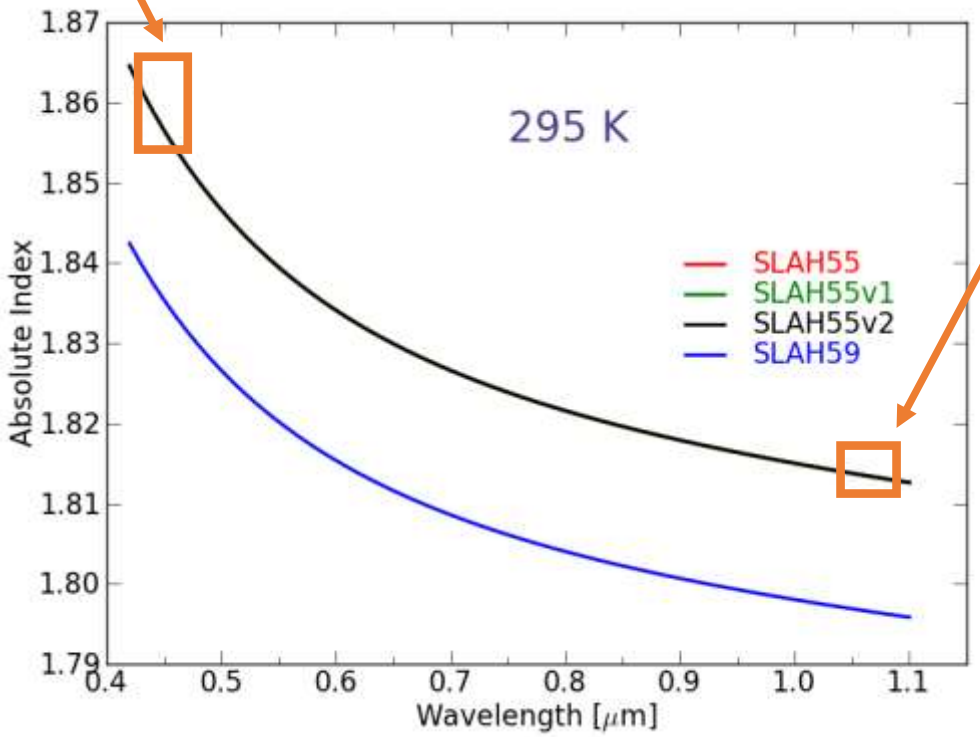




S-LAH55, S-LAH55V, S-LAH59





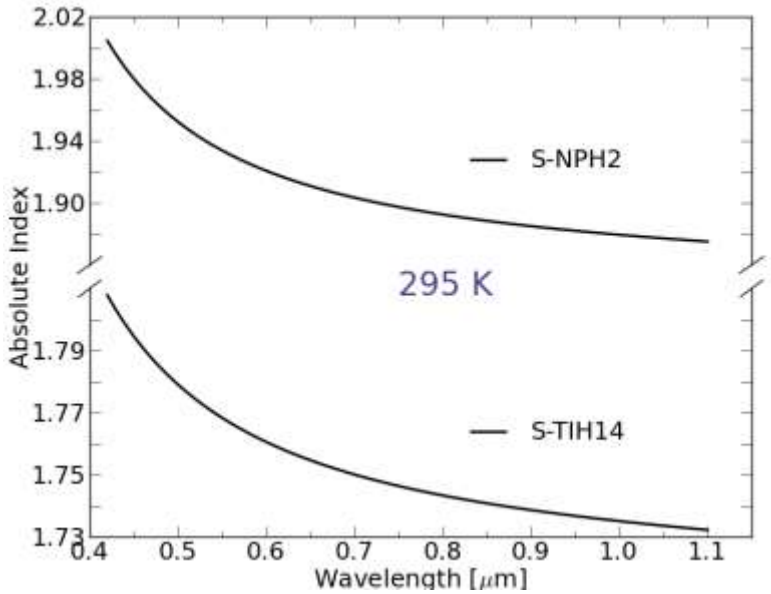


Constituent % by weight	S-LAH55	S-LAH59
La_2O_3	40-50 %	20-30 %
Gd_2O_3	2-20 %	30-40%

S-TIH14 & S-NPH2

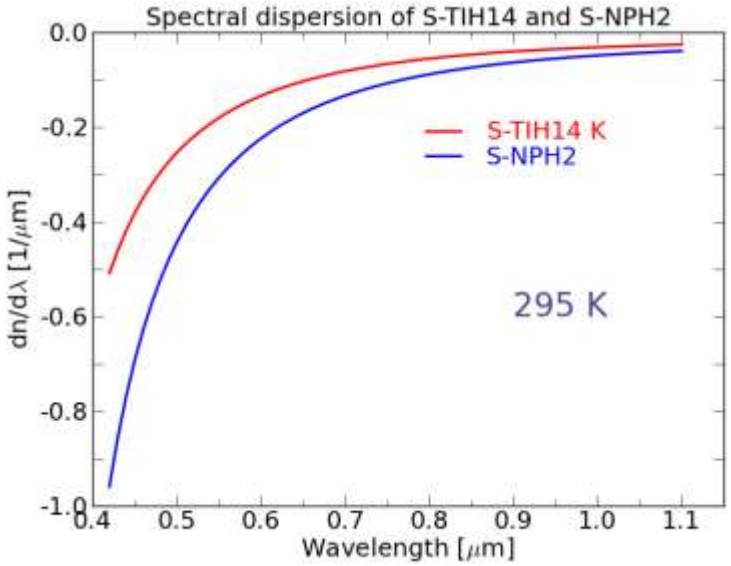
TiO_2 : 20—40 %

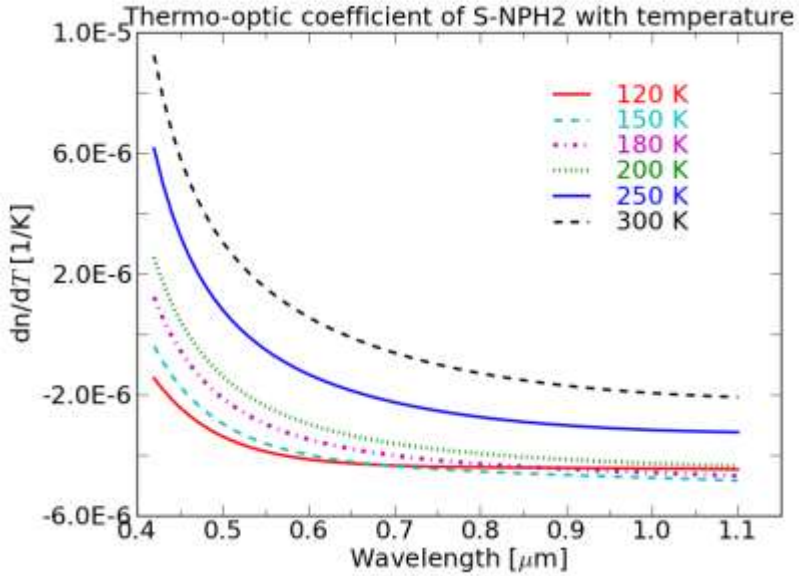
SiO_2 : 30—50 %



Nb_2O_5 : 40—50 %

P_2O_5 : 20—30 %





S-LAM3, S-NBM51, S-PHM52

La_2O_3 : 10—20 %

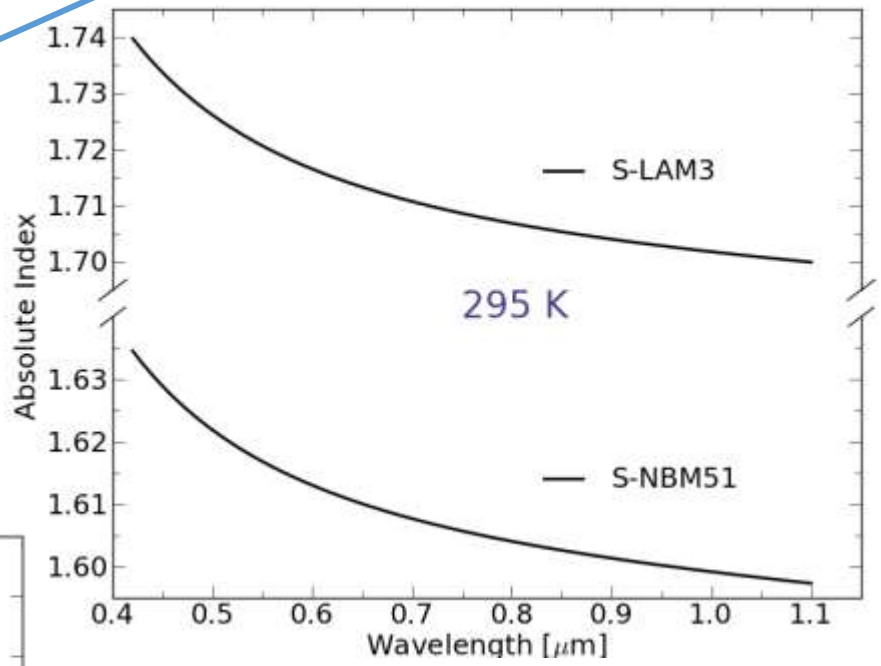
BaO : 40—50 %

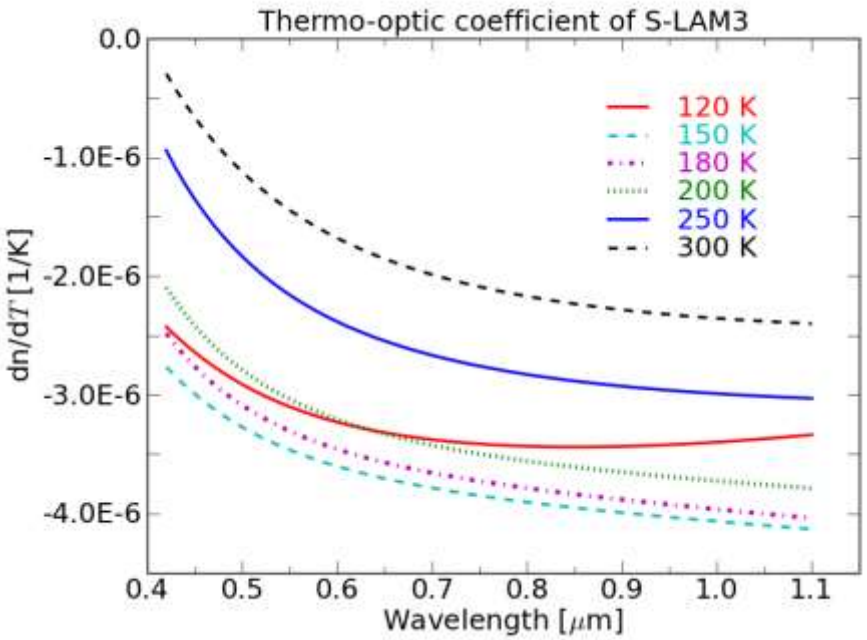
Nb_2O_5 : 10—20 %

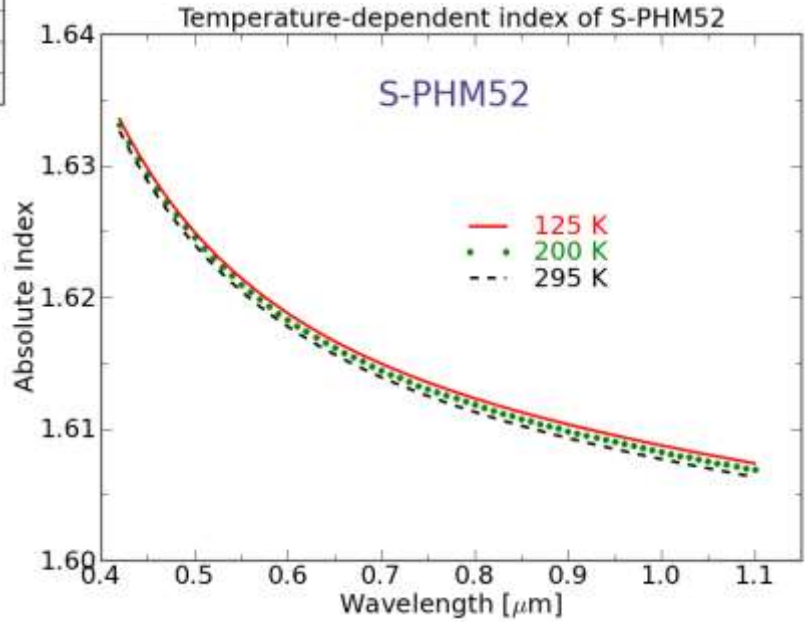
SiO_2 : 30—40 %

P_2O_5 : 40—50 %

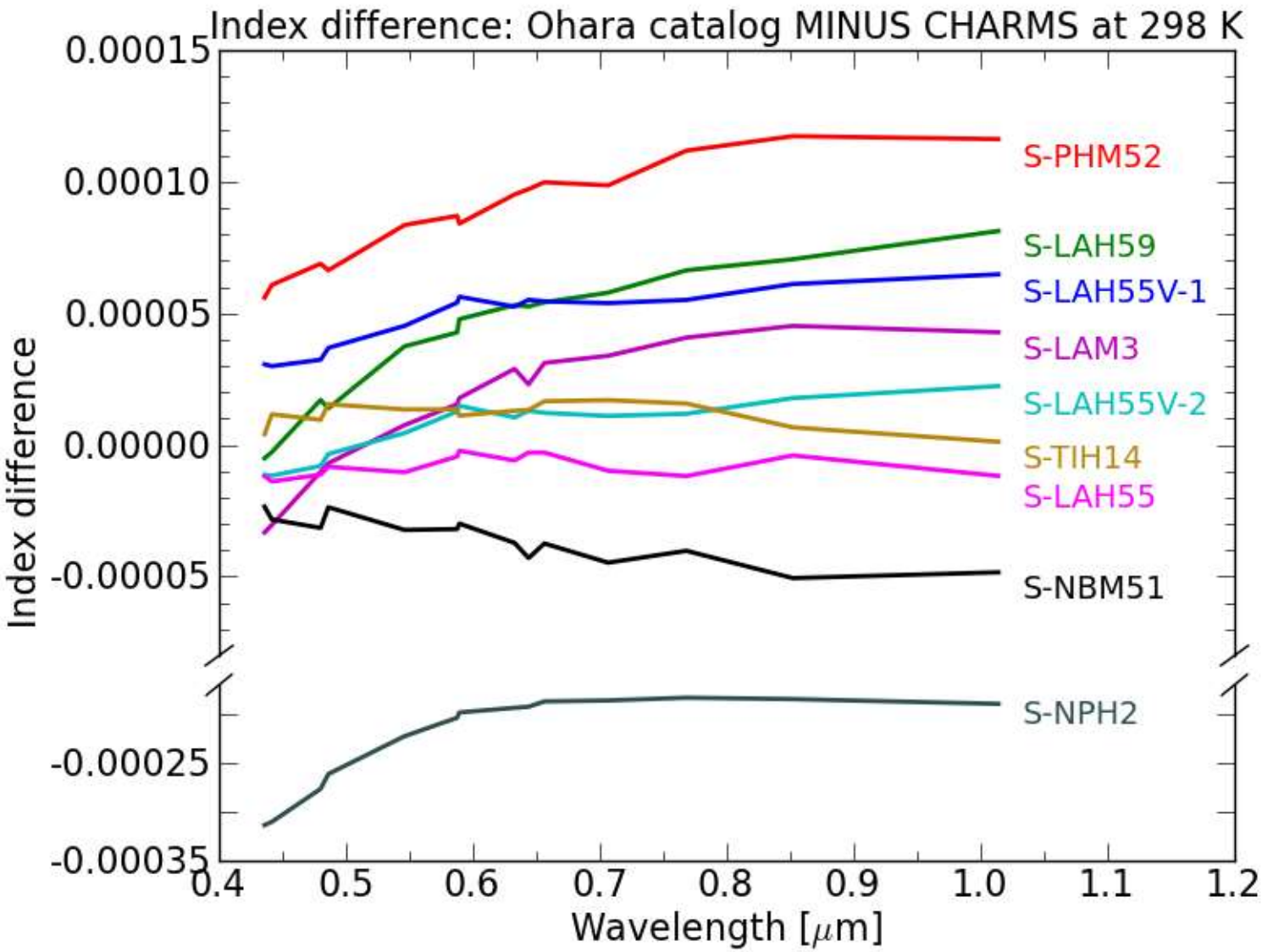
BaO : 30—40 %





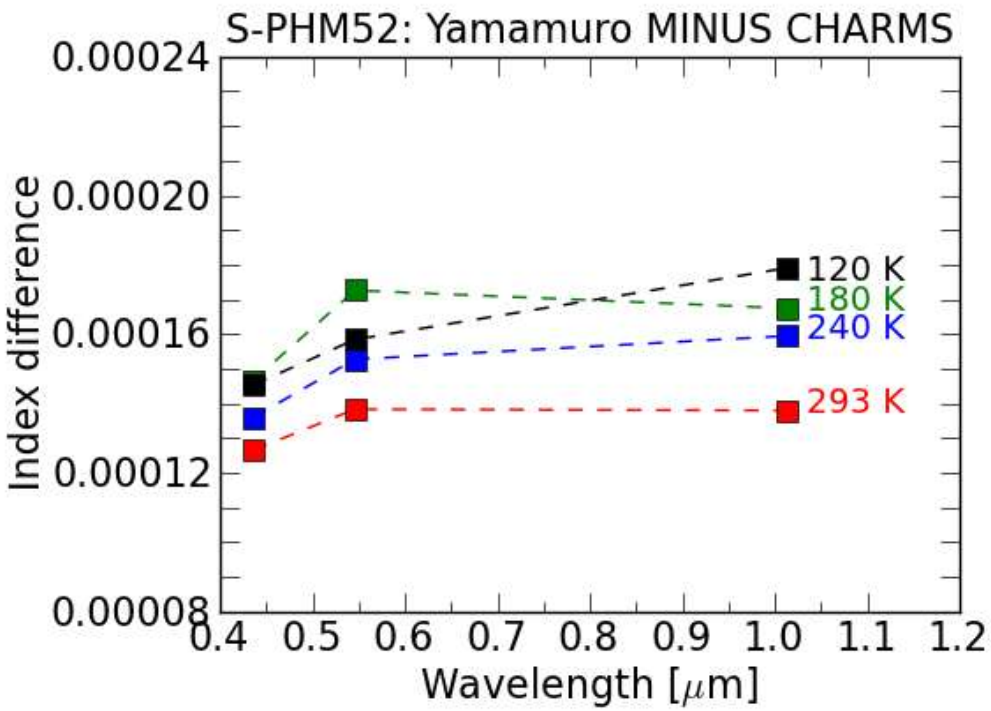


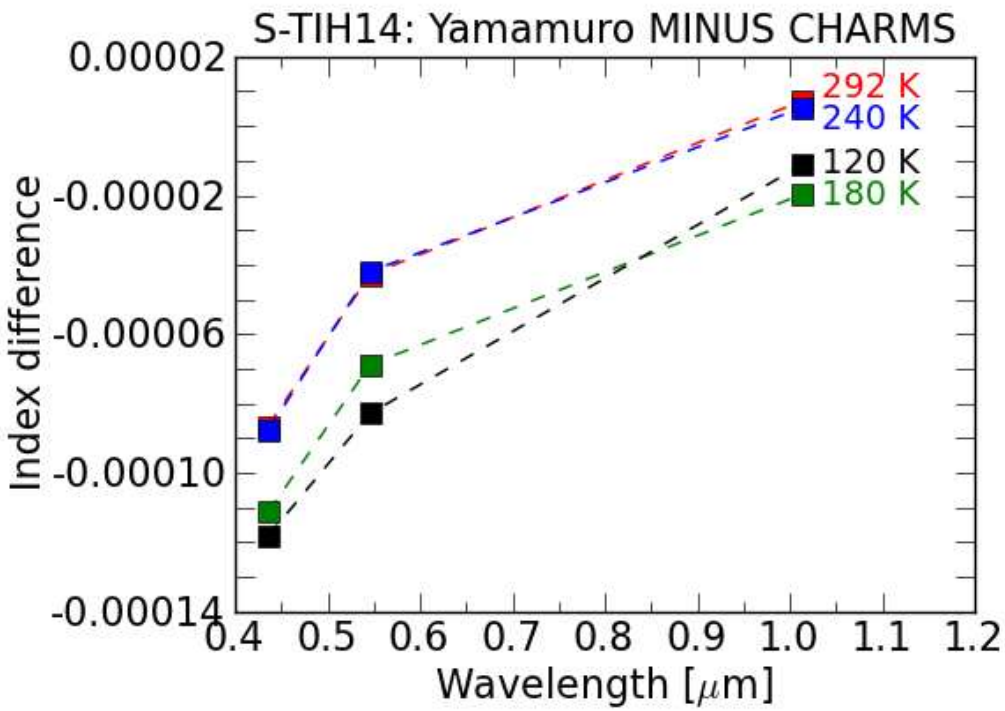
Index Comparison: Ohara MINUS CHARMS



Ohara Optical Glass Catalog, http://Oharacorp.com/

Cryogenic Index Comparison: Yamamuro MINUS CHARMS





Yamamuro, T. et al., Optical Engineering 45(8), 083401 (2006)

Conclusions